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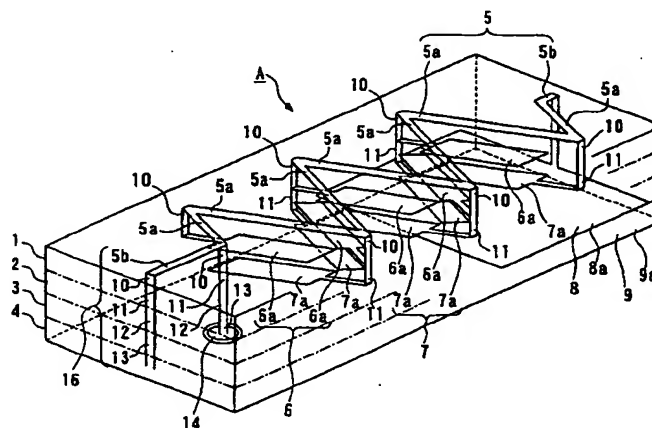
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### (54) Antenna

(57) An antenna (A) includes a plurality of bases (1 to 4) stacked in the thickness direction, conductor patterns (5 to 9) formed on the bases (1 to 4), respectively, and conducting sections (10 to 13) for electrically inter-

connecting the conductor patterns (5 to 9). The conductor patterns (5 to 9) form inductance components and capacitance components.

Fig.1



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## Description

**[0001]** The present invention relates to antennas incorporated into various apparatuses, such as various communication apparatuses for transmitting and receiving radio waves, which have functions of transmitting and receiving radio waves.

**[0002]** Recently, various apparatuses, such as communications apparatuses for transmitting and receiving radio waves, which have functions of transmitting and receiving radio waves in a broad sense are in increasing demand. Accordingly, an increasing number of antennas used within a frequency band from a few hundreds of MHz to a few GHz have been employed. These antennas are used in, for example, mobile communication, next-generation transportation systems, and non-contact cards used in automatic ticket readers. Methods for performing wireless data communication without using long, burdensome cables have been introduced, including wireless communication between cordless Internet appliances, wireless local area networks (LAN), and for Bluetooth. The above antennas are expected to be widely used in these fields. The antennas are also used in wireless data transmission and reception from various terminals. The demand for the antennas is increasing in the fields of telemetering for communicating safety management information concerning waterworks and gas systems by radio waves, point-of-sale (POS) systems for banking terminals, and the like. Moreover, the antennas are applicable to home appliances including televisions, such as portable satellite broadcasting receivers, and for automatic vending machines. The range of uses of the antennas is very broad.

**[0003]** As antennas for use in apparatuses having functions of transmitting and receiving radio waves, retractable monopole antennas, which are mounted on casings of the apparatuses, are mainly used. In addition, helical antennas, which slightly protrude to the outside of the casings, are known.

**[0004]** The conventional antennas, such as the monopole antennas, are disadvantageous in that it is burdensome to handle the monopole antennas and in that the monopole antennas are easily damaged since they are required to be extended during used. The helical antennas are disadvantageous in that, since antenna elements formed of air core coils are protected by covering materials such as a resin, the outer dimensions tend to be greater. When the helical antennas are fixed so that they protrude from the casings, the overall appearance is not satisfactory.

**[0005]** In order to solve the above problems, it is an object of the present invention to provide a small antenna to be attached to the interior of a casing of each of various types of apparatuses, including various communication apparatuses for transmitting and receiving radio waves, which have functions of transmitting and receiving radio waves, so that it is not necessary to

extend the antenna, the antenna is not easily damaged, and the overall appearance is not worsened.

**[0006]** According to an aspect of the present invention, an antenna is provided including a plurality of bases stacked in the thickness direction, conductor patterns each formed on the bases, and conducting sections for electrically interconnecting the conductor patterns formed on the bases. The conductor patterns form inductance components and capacitance components.

**[0007]** With this configuration, a resonant system required to transmit and receive radio waves is configured with the inductance components and the capacitance components, and hence the resonant system functions as an antenna.

**[0008]** Among the conductor patterns formed on the bases, a capacitance component may be constructed of a conductor pattern formed on a first base and a conductor pattern formed on a second base. An inductance component may be constructed of at least one of the two conductor patterns. The capacitance component and the inductance component may be connected in parallel.

**[0009]** With this configuration, the capacitance component and the inductance component formed of the conductor patterns are connected in parallel to form the resonant system required to transmit and receive radio waves, which functions as the antenna.

**[0010]** The conductor patterns may include capacitance patterns and inductance patterns. Among the bases, an inductance pattern may be formed on a first base. A first capacitance pattern may be formed on a second base adjoining the first base. A second capacitance pattern, which is opposed to the first capacitance pattern to form a capacitance component, may be formed on a third base adjoining the second base. The inductance pattern and the capacitance component formed by the first and the second capacitance patterns may be connected in parallel by the connecting section.

**[0011]** With this arrangement, the capacitance component and the inductance component formed of the conductor patterns are connected in parallel to form the resonant system required to transmit and receive radio waves, which functions as the antenna.

**[0012]** On a surface of the outermost base among the bases, a shielding conductor pattern may be formed so as to be exposed to the outside. In plan view, the shielding conductor pattern may be disposed on the conductor patterns formed on other bases.

**[0013]** With this arrangement, the shielding conductor pattern shields the antenna from radio waves. When transmitting radio waves, no radio waves are emitted in the conductor pattern direction. The antenna is also shielded from electromagnetic noise from the conductor pattern direction.

**[0014]** A power feeding port may be formed on the surface of the outermost base so as to be exposed to the outside. A connecting section to be connected to

another electronic component may be configured by the power feeding port and the shielding conductor pattern.

[0015] With this arrangement, the parts to be connected with another electronic component, namely, the power feeding port and the shielding conductor pattern, are coplanar. Hence, the antenna can be mounted on the electronic component at the coplanar surface.

[0016] A trimming pattern for trimming the impedance of the entire antenna may be formed on the bases.

[0017] With this configuration, the impedance of the entire antenna can be changed to an arbitrary value by altering the shape of the trimming pattern in accordance with the necessary frequency.

[0018] The conducting sections may include through holes formed in the thickness direction of the bases.

[0019] With this arrangement, in plan view, the conductor patterns are configured to be connected at a single point.

[0020] Preferably, the bases are protected by a covering while the shielding conductor pattern and the power feeding port are exposed to the outside.

[0021] According to the present invention, a small antenna is provided, which can be attached to the interior of a casing of each of various apparatuses, such as portable communication terminals, which have functions of transmitting and receiving radio waves. It is thus not necessary to extend the antenna, and hence the antenna is not easily damaged and the overall appearance is improved. The present invention is particularly advantageous when used in a frequency bands with long wavelength, such as with the very high frequency (VHF) band and the ultra high frequency (UHF) band. By stacking a plurality of bases, a plurality of resonance modes are obtained by a plurality of capacitance components while the overall length remains the same.

[0022] According to the present invention, transmission of radio waves in the conductor pattern direction is blocked. Therefore, the antenna gains in the direction of areas in which the conductor patterns are absent are improved. It is thus possible to increase the transmission distance compared with a case in which no conductor pattern is used. At the same time, the antenna is shielded from noise from a radio transmitting and receiving circuit. It is thus possible to directly mount the antenna on a circuit board, allowing more freedom in choosing the mounting location. This is advantageous in that the antenna can be attached to the interior of a casing of each of the apparatuses having functions of transmitting and receiving radio waves.

[0023] According to the present invention, a connection section can be connected with solder to another electronic component, such as a printed board forming a radio transmitting and receiving circuit. This allows space saving when attaching the antenna to the interior of a casing of each of various apparatuses having functions of transmitting and receiving radio waves. The present invention is advantageous for trimming the

impedance between a resonant system and a radio transmitting and receiving circuit system to be connected to the resonant system. When connecting a plurality of conductor patterns, no space is necessary. This is advantageous for the reduction of the outer dimensions. An exposed surface can be used as a mounting surface to be mounted on a transmission circuit board. Once the antenna is mounted, effects of oxidation of the conductor patterns and damage caused by external forces on radio transmission and reception are minimized.

Fig. 1 is a perspective view of an antenna according to an embodiment of the present invention, part of the antenna being omitted; and

Fig. 2 is a front view of conducting sections illustrating the positional relationships between the conducting sections.

[0024] The present invention will be understood from the following description of the preferred embodiment taken in conjunction with the accompanying drawings.

[0025] Referring to Figs. 1 and 2, an antenna A includes a plurality of bases 1 to 4 stacked in the thickness direction, conductor patterns 5 to 9 formed on the bases 1 to 4, respectively, and conducting sections (through holes) 10 to 13 for electrically interconnecting the conductor patterns 5 to 9.

[0026] On surfaces of the bases 1 to 4, the conductor patterns are formed of noble metals such as gold and silver by printing or the like. Subsequent to perforating the bases 1 to 4, the bases 1 to 4 are stacked one after another. The perforated holes are filled with conductive materials, and hence the through holes are formed. The bases 1 to 4 are baked and integrated.

[0027] The conductor patterns 5 to 9 include capacitance patterns 6a and 7a which mainly contribute to forming capacitance components and inductance patterns 5a which mainly contribute to forming inductance components.

[0028] The conductor pattern 5 formed on the base 1 (first base) is formed of a zigzag conductor (inductance patterns 5a) arranged with a predetermined pitch. The conductor pattern 5 includes linear sections 5b at both ends thereof.

[0029] The conductor pattern 6 formed on the base 2 (second base) and the conductor pattern 7 formed on the base 3 (third base) are formed including the capacitance patterns 6a and 7a, which are a plurality of rectangular patterns each having a linear section at one end. In plan view, these patterns 6a and 7a of the conductor patterns 6 and 7 are disposed so that one is superposed on the other.

[0030] The conductor pattern 8 includes a capacitance pattern 8a. The capacitance pattern 8a is formed as a single rectangular pattern on the base 4.

[0031] The conductor pattern 9 includes a pattern

9a serving both as a capacitance pattern and a shielding pattern. The conductor pattern 9 is formed as a connecting section to be connected to a printed board which forms a radio transmitting and receiving circuit. The conductor pattern 9 is formed on the outermost base 4 so as to be exposed to the outside. In this case, in plan view, the pattern 9a is disposed so as to overlap with the conductor patterns formed on the other bases.

**[0032]** The patterns 6a of the conductor pattern 6 and the patterns 7a of the conductor pattern 7 are connected to both ends of the patterns 5a.

**[0033]** The conductor pattern 8 is connected to one terminal of the conductor pattern 5 by the conducting sections 10 to 12.

**[0034]** The conductor pattern 9 is connected to the other terminal of the conductor pattern 5 by the conducting sections 10 to 13.

**[0035]** A power feeding port 14, which forms the connecting section to be connected to the printed board forming the radio transmitting and receiving circuit, is provided outside the outermost base 4. The power feeding port 14 is connected to the conductor pattern 5 through the conducting sections 10 to 13. In this configuration, the pattern 5b of the conductor pattern 5 and the conducting sections 10 to 13 form a trimming pattern 16.

**[0036]** Referring to Fig. 2, a protective covering 15 made of synthetic resin is provided outside the entirety of the stacked bases 1 to 4 while the conductor pattern 9 and the power feeding port 14 are exposed to the outside.

**[0037]** According to the antenna, inductance components are formed by the patterns 5a of the conductor pattern 5, and capacitance components are formed between the conductor patterns 6 and 7. The inductance components and the capacitance components form parallel resonant circuits, which function as a resonant system required to transmit and receive radio waves. The parallel resonant circuits are connected in series, and the overall length thereof forms a radio transmitter and receiver, thereby constructing an array-type antenna. In this configuration, a predetermined resonant frequency is set based on the length of the patterns 5a of the conductor pattern 5, the inductance given by the linear sections of the conductor patterns 6 and 7 and the conducting sections 10 to 13, the areas of the patterns 6a and 7a of the conductor patterns 6 and 7, and the distance between the conductor patterns.

**[0038]** According to the antenna, the inductance components and the capacitance components formed by the conductor patterns 5 to 9 form the resonant system required to transmit and receive radio waves, which functions as an antenna.

**[0039]** The patterns 5a of the conductor pattern 5 can emit horizontal wave components in the diagonal direction of the zigzag sides and vertical wave components along the intersections of the zigzag sides. When the antenna is formed on the same plane at positions

differing in the right-angle direction, radio waves of horizontally polarized waves and vertically polarized waves can be transmitted and received in a more satisfactory manner.

**[0040]** Since the pattern 9a of the conductor pattern 9 shields the antenna from radio waves, radio transmission in this direction is blocked. The antenna gains in the opposite direction are improved. Compared with a case in which no conductor pattern 9 is used, the transmission distance is increased. At the same time, the antenna is shielded from noise from the radio transmitting and receiving circuit. Accordingly, it is possible to directly mount the antenna on a circuit board and to allow freedom in selecting the mounting location. This is advantageous in that the antenna can be attached to the interior of a casing of each of various apparatuses having functions of transmitting and receiving radio waves.

**[0041]** The conductor pattern 9 and the power feeding port 14 are formed on the surface of the outermost base 4 to be exposed to the outside, and this section is regarded as the connecting section. Hence, it is possible to directly mount the antenna with solder on a printed board, which forms the radio transmitting and receiving circuit, at that surface. This allows space saving when attaching the antenna to the interior of a casing of each of various apparatuses having functions of transmitting and receiving radio waves.

**[0042]** The inductance components are formed by the linear section 5b of the conductor pattern 5, which is from the position at which the power feeding port 14 is connected to the conductor pattern 5 to the terminal of the conductor pattern 5, and the conducting sections 10 to 13 toward the conductor pattern 9. Hence, the impedance of the entire antenna can be trimmed. It is thus possible to trim the impedance between the entire antenna and the radio transmitting and receiving circuit system to be connected to the antenna.

**[0043]** Since the conducting sections 10 to 13 are formed of the through holes formed in the thickness direction of the bases 1 to 4, no space is required when connecting a plurality of conductor patterns. This is advantageous for the reduction of the outer dimensions. In this case, glass epoxy instead of ceramic is used to form the bases 1 to 4. The holes are coated with conductor materials, and the through holes are formed. Alternatively, the holes may be filled with a paste and be baked. This is advantageous for reducing the impedance of the antenna.

**[0044]** Since the bases 1 to 4 are protected by the covering 15 while the conductor pattern 9 and the power feeding port 14 are exposed to the outside, the antenna can be mounted on the transmitting circuit board at the exposed surface, i.e., the mounting surface. Once the antenna is mounted, it is possible to minimize effects of oxidation of the conductor patterns and damage caused by external forces on radio transmission and reception.

**Claims****1.** An antenna (A) characterized by comprising:

a plurality of bases (1 to 4) stacked in the thickness direction;  
 conductor patterns (5 to 9) formed on the bases (1 to 4), respectively; and  
 conducting sections (10 to 13) for electrically interconnecting the conductor patterns (5 to 9) formed on the bases (1 to 4);  
 the conductor patterns (5 to 9) forming inductance components and capacitance components.

**2.** An antenna (A) according to Claim 1, characterized in that:

the capacitance component is formed by, among the conductor patterns (5 to 9) formed on the bases, a conductor pattern (5) formed on a first base (1) and a conductor pattern (6) formed on a second base (2);  
 at least one of the two conductor patterns (5 and 6) forms the inductance component; and  
 the capacitance component and the inductance component are connected in parallel by the conducting section (10).

**3.** An antenna (A) according to Claim 1, characterized in that:

the conducting patterns (5 to 9) include capacitance patterns and inductance patterns;  
 one inductance pattern (5a) is formed on a first base (1) among the plurality of bases (1 to 4);  
 a first capacitance pattern (6a) is formed on a second base (2) adjoining the first base (1);  
 a second capacitance pattern (7a), which is opposed to the first capacitance pattern (6a) to form a capacitance component, is formed on a third base (3) adjoining the second base (2);  
 and  
 the one inductance pattern (5a) and the capacitance component formed by the first and the second capacitance patterns (6a and 7a) are connected in parallel by the conducting sections (10 and 11).

**4.** An antenna (A) according to any one of Claims 1 to 3, characterized in that a shielding conductor pattern (9a) is formed on a surface of the outermost base (4), among the bases (1 to 4), the shielding conductor pattern (9a) being exposed to the outside, and in plan view, the shielding conductor pattern (9a) being superimposed on the conductor patterns (5 to 8) formed on the other bases (1 to 4).**5.** An antenna (A) according to Claim 4, characterized in that:

a power feeding port (14) is formed so as to be exposed outside the surface of the outermost base (4); and  
 the power feeding port (14) and the shielding conductor pattern (9a) are used as a connecting section to be connected to another electronic component.

**6.** An antenna (A) according to one of Claims 4 and 5, characterized in that a trimming pattern (16) for trimming the impedance of the entire antenna (A) is formed on the bases (1 to 4).**7.** An antenna (A) according to any one of Claims 1 to 6, characterized in that the conducting sections (10 to 13) include through holes formed in the thickness direction of the bases (1 to 4).**8.** An antenna (A) according to one of Claims 5 and 7, characterized in that the bases (1 to 4) are protected by a covering (15) while the shielding conductor pattern (9a) and the power feeding port (14) are exposed to the outside.

Fig.1

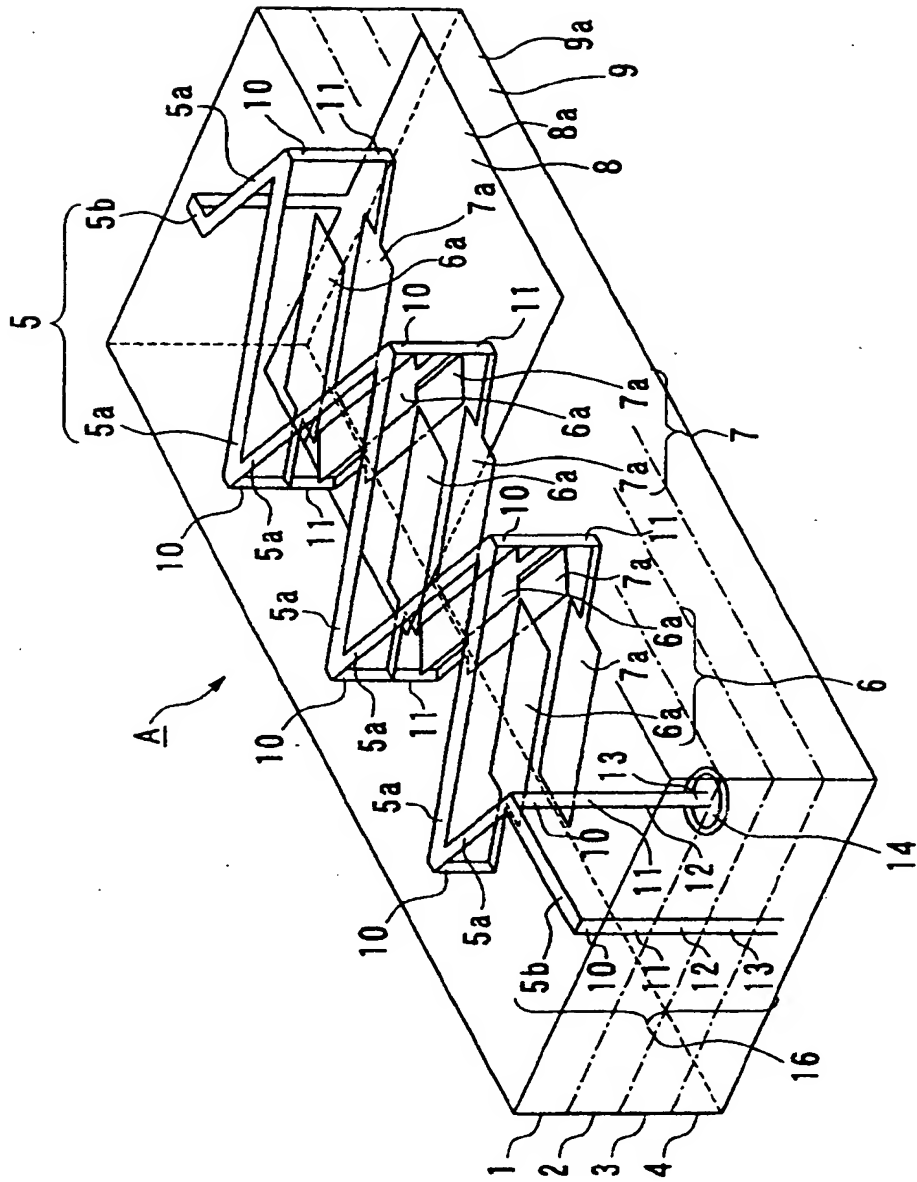
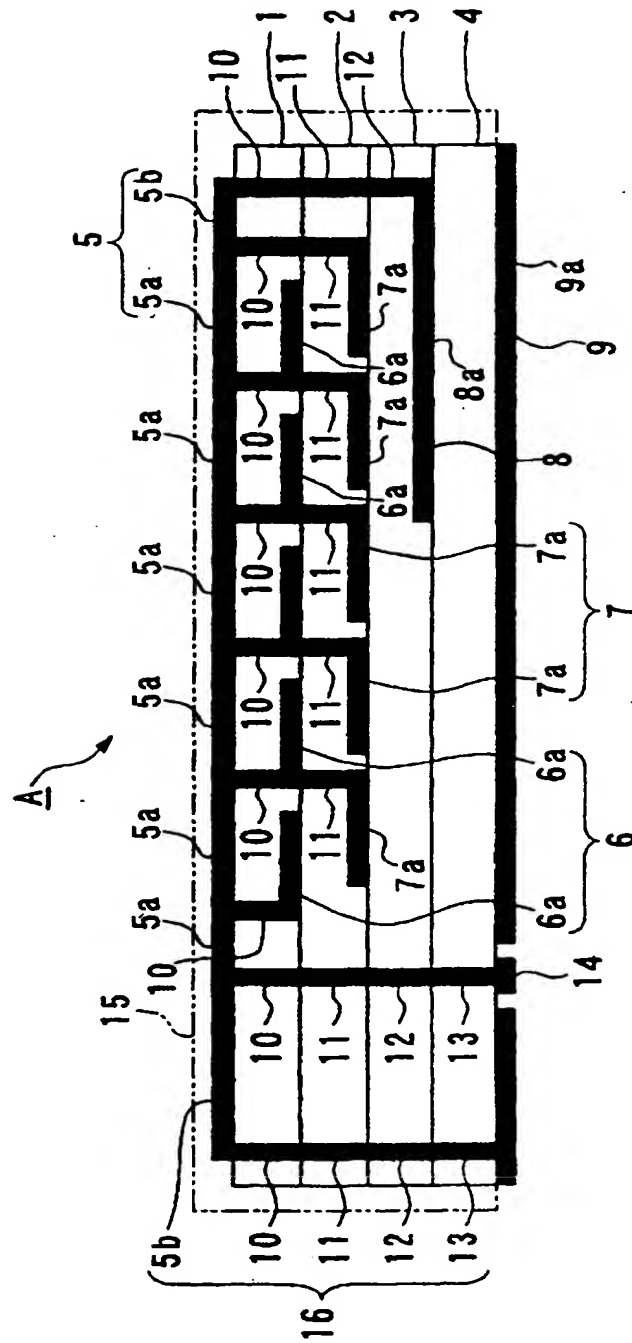


Fig.2



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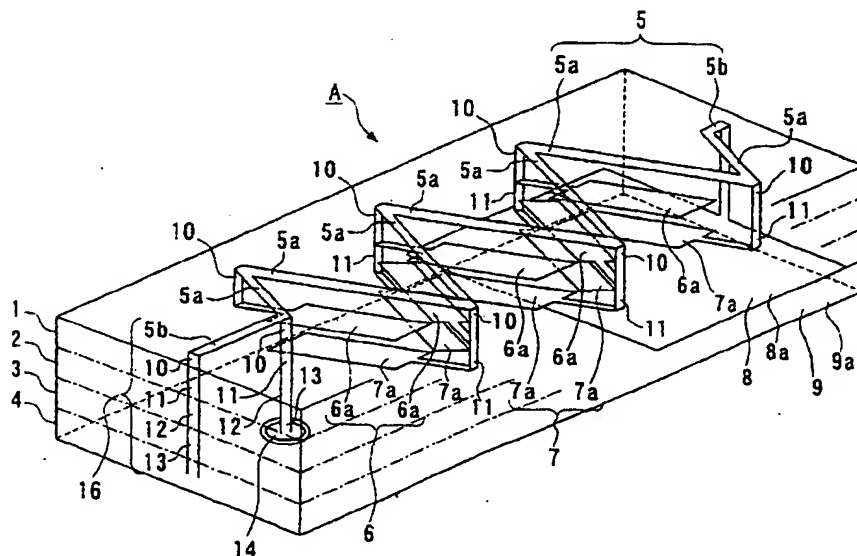
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### (54) Antenna

(57) A chip antenna (A) includes a plurality of layers (1 to 4) stacked in the thickness direction, conductor patterns (5 to 9) formed on the layers (1 to 4), respectively,

and conducting sections (10 to 13) for electrically inter-connecting the conductor patterns (5 to 9). The conductor patterns (5 to 9) form inductance components and capacitance components.

Fig.1







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Application Number  
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Y	* figures 1-3 *	4-6,8	
Y	US 5 173 711 A (TAKEUCHI KAZUNORI ET AL) 22 December 1992 (1992-12-22) * column 1, line 52 - line 57; figure 1B * * column 5, line 21 - line 26; figure 2 *	4-6,8	
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			H01Q
The present search report has been drawn up for all claims			
Place of search MUNICH		Date of completion of the search 16 January 2003	Examiner Jäschke, H
<p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons &amp; : member of the same patent family, corresponding document</p>			

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